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North Dakota
Agricultural Experiment Station

Other Grains Than Wheat in Bread Making
By W. L. Stockham

and

Milling Value of Barley
By Thomas Sanderson

Bulletin No. 123

Agricultural College, North Dakota

October 1917

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OTHER GRAINS THAN WHEAT IN BREAD MAKING

By W. L. Stockham

The shortage in wheat may make it necessary to mill more of the wheat into flour than has been the custom and to use other grains to some extent in bread making. The availability of other cereals is dependent not only on the quantity produced but upon special milling facilities and an understanding of how to properly prepare them for use. It is also necessary to determine the quality of bread that can be made from them either alone or in combination with wheat flour.

Rye flour is similar to wheat flour in production factors. It is commonly used in connection with wheat flour in restaurants and since it can often be purchased somewhat cheaper than wheat flour more of it should be used in the home. Rye flour when used alone makes a bread with a strong rye odor and flavor. This is less pronounced in the higher grades which are likely the only ones to be used alone. To determine the relative value of the lower grades of rye flour, President Ladd secured two samples of rye flour from a commercial rye mill. One a pure medium colored rye flour, representing between 75 and 80 percent of the kernel and designated as No. 100, and a lower grade from a similar percentage extraction designated as No. 15X, the better half of the flour having been taken out as white rye flour. Assuming that a light color would be of no special value in blends of this kind, and in the interests of economy, a low grade wheat flour was used with the rye. Photographs of the bread are shown in figures 1 and 2.

The wheat flour used in the blends when baked alone had only a fair flavor for a low grade wheat flour of its class. Those who have not developed a taste for rye bread would likely prefer that containing the smaller amounts of the straight rye flour, but those who like the rye would probably prefer about a 25 percent mixture of the lower grade No. 15X rye. For most people any higher percentage would be too strong and the difficulty in baking would lead to greater loss of the finished product.

Because of ease of manipulation and greater strength the higher grade wheat flours can carry more rye but might not be as satisfactory to many as the lower grade blends because of the lower price of the latter. The lower grade rye has a much greater water absorbing power than the wheat or the higher grade rye flour.

But little barley has been milled in the United States to date and just what its possibilities are, is not very well understood. Some experiments were made in the experimental mill to show what could be expected of it. Its milling value is discussed in connection with this paper by Thomas Sanderson.

A series of blends with the two grades of barley flour with a wheat flour were baked (see fig. 3) to determine its adaptability for bread making. As much as 25 percent of the higher grade barley flour in the blend is hardly noticeable and produces a very mild barley flavor, but when barley is milled closer, its flavor is so much stronger that 25 percent of barley in the blend is about all it can carry. Bar-

TABLE I. BAKING REPORT ON COMMERCIAL RYE FLOUR AND RYE WHEAT BLENDS

Sample	Water absorption	Loaf volume	Color score	Texture score	Flavor	Remarks
	Perc'nt	C. c.				
No. 15X Rye[1]	73.5	760	10	10	Very strong, bitter	Extremely dark, very compact
No. 100 Rye[2]	62.1	750	28	10	Very strong, bitter	Extremely dark, very compact
2nd clear wheat flour	67.7	1900	55	78	Characteristic 2nd clear	Brownish
No. 15X rye 10% & 2nd clear wheat flour 90%	64.7	1780	42	72	Mild rye flavor	Dark brown
No. 15X rye 15% & 2nd clear wheat flour 85%	66.2	1610	37	65	Rye flavor	Dark brown
No. 15X rye 25% & 2nd clear wheat flour 75%	67.7	1400	35	50	Decided rye flavor	Very dark brown
No. 15X rye 50% & 2nd clear wheat flour 50%	73.5	1120	20	43	Very strong rye, after taste	Extremely dark
No. 100 rye 10% & 2nd clear wheat flour 90%	62.6	1950	50	76	Mild rye flavor	Dark brown
No. 100 rye 15% & 2nd clear wheat flour 85%	62.1	1710	44	73	Mild rye flavor	Dark brown
No. 100 rye 25% & 2nd clear wheat flour 75%	62.4	1480	40	65	Rye flavor	Dark brown
Good grade wheat flour used in the following blends	64.1	2170	94	92		Creamy gray
No. 15X rye 15% & wheat flour 85%	64.1	2010	48	83	Mild rye flavor	Brownish
No. 100 rye 15% & wheat flour 85%	61.2	2070	68	87	Mild rye flavor	

[1] Low grade rye flour.
[2] Straight grade rye flour.

TABLE II. BAKING RESULTS WITH BARLEY FLOUR AND BARLEY-WHEAT BLENDS

Sample	Water absorption	Loaf volume	Color score	Texture score	Flavor	Remarks
	Perc'nt	C. c.				
High grade barley flour[1]	55.6	1250	30	45	Somewhat strong	Very dark, grayish brown
Wheat flour used in blending	64.1	2170	94	92	Wheat bread flavor	Creamy gray
10% high grade barley flour	65.3	2110	88	91	Presence of barley not noticeable	Gray
25% high grade barley flour	61.5	2080	81	89	Mild barley	Very gray
Low grade barley flour[2]	78.2	740	28	10	Very strong, somewhat bitter	Very dark brown
10% low grade barley flour	67.7	2040	62	86	Barley flavor	Bluish gray
25% low grade barley flour	67.7	1700	49	68	Strong barley flavor	Very dark gray

[1] Thirty percent of entire kernel. No. 3573.
[2] Sixty-eight percent of entire kernel. No. 3573A.

ley dough is more sticky than wheat dough but less sticky than that from rye and like the latter when milled close and baked alone is too strong to be relished by the average American. It also has a greater water absorbing power than wheat but neither barley nor rye retain their moisture as well as the wheat. Straight rye and barley flour each make a very compact loaf. The denser loaves require more time in baking which tends to equalize the increased water absorption by permitting more evaporation.

When wheat flour is wet the proteins contained within it adhere to form a sticky, elastic mass known as gluten. The gluten, encasing starch and other constituents forms the dough. Gas formed by the action of yeast makes bubbles within the dough which cannot escape because of this gluten. The increase in size of these bubbles causes the bread to rise. By kneading the dough the yeast cells which have become more numerous thru division are uniformly distributed thruout the dough and gas is produced at an increased number of points. The bubbles will thus be more abundant but smaller and of more uniform size. When the dough is baked the places where the gas was held remain as holes. If the dough has over-raised or is too weak the gluten walls between the gas bubbles give way, forming larger bubbles which results in a coarse bread or a collapse. Wheat is the only one of the commonly used cereals which contains gluten. If one desires to make a good light bread, wheat flour must form the basis for it and the limit to the amount of other cereals which may be added

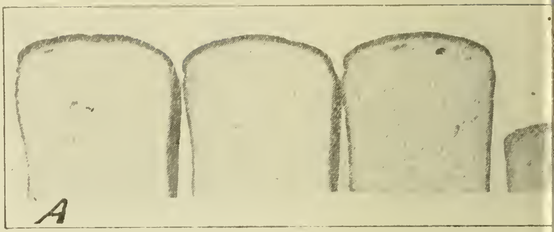


Fig. 1—Rye and rye-wh

Straight grade wheat flour
15 percent rye No. 100 }
15 percent rye No. 15X } ....
Straight rye No. 100
25 percent rye No. 100 }
15 percent rye No. 100 } ....
10 percent rye No. 100 }

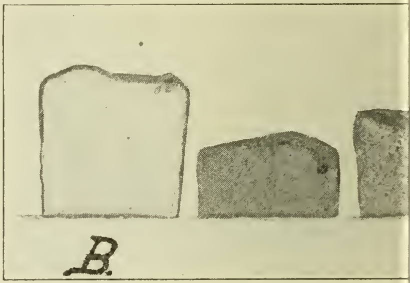


Fig. 2—Rye and rye-wh

Wheat flour, 2nd clear
Low grade rye No. 15X
50 percent rye No. 15X }
25 percent rye No. 15X } ....
10 percent rye No. 15X }

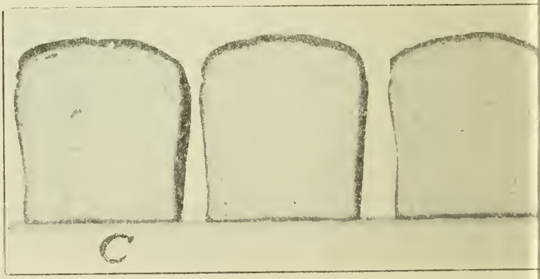
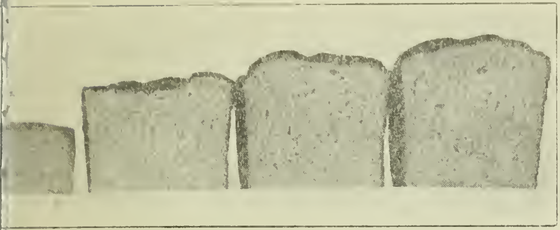


Fig. 3—Barley and wheat

Wheat flour used in blending
High grade barley flour[1] 10 percent.
High grade barley flour 25 percent.

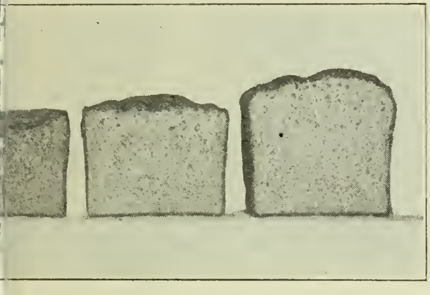
[1] High grade, 30 percent of kernel, No. 3573.



mixtures—left to right.

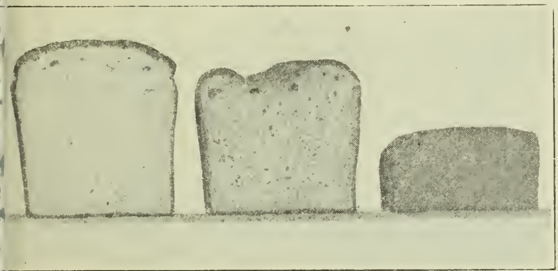
Blended with straight grade wheat flour

......Blended with 2nd clear wheat flour



t mixtures—left to right

......Blended with 2nd clear wheat flour



our mixtures—left to right

Lower grade barley flour[2] 10 percent.
Lower grade barley flour 25 percent.
Lower grade barley flour alone.
Lower grade, 68 percent of kernel, No. 3573A.

is determined by their influence in weakening, as well as diluting the gluten. Protein material from other cereals, eggs and other substances may retain gas but they do not compare with wheat gluten for bread making and have not the body or tenacity to bear much pressure. Gluten is affected differently by acids, salts, sugar, fats, other proteins and the ferments secreted by the germs of the cereals. Substances like starch are more or less inert but all have a diluting and modifying influence. The protein substances in the outer wheat coats and in the other cereals with the exception of gliadin in rye are not constituents of gluten and their addition almost always affects the elasticity of the gluten and dough adversely, lowering its power to hold gas.

The ability of a flour to make a large good-textured loaf is its 'strength'. In some cases lack of gas production causes weakness but this can be overcome artificially. Lack of ability to retain the gas generated by the yeast is more often the difficulty and usually cannot be overcome except by mixing with flour of superior strength.

SHOULD THE ENTIRE WHEAT KERNEL BE REDUCED TO FLOUR OR THE PRODUCT MADE CHEAPER BY ADMIXTURE OF FLOUR FROM OTHER CEREALS?

The modern milling process is very well developed and although family patent grades have the preference, practically all of the endosperm of the kernel that can be recovered is marketed in the various grades of white flour. When the wheat is first crushed on the rolls some flour is formed and this with that last removed from the shorts particles goes into the lower grades. The patent grades come from the reduction of the large particles of endosperm after they have been purified by air currents. All the grades of flour that people care for is used for human consumption and the remainder is used for paste or as stock feed. Any increase in the percentage of flour would render the dough more sticky and ''runny'' and it would also result in a waste of more bread because of the introduction of ferments, the inclusion of more bacteria, and the decrease in gas retaining power, and this in turn would require more skill in baking. With the higher grade flours the method of making bread may be modified freely without seriously injuring the product. With the lower grades fermentation is quickened, the periods of sponging and raising may be changed only within narrow limits and the temperature must be more carefully controlled. Such increase in percentage of flour would also render the introduction of other cereals less satisfactory. Those desiring the laxative properties in the coarser part of the wheat kernel can add the bran and shorts separately. The whole wheat bread of the housewife is usually made from three-fourths or more high grade white flour and one-fourth or less whole wheat flour. Such a loaf would be very much better than one of similar color made by increasing the percentage of flour by close milling as the former would contain the higher percentage of strong flour.

From the nutrition experiments of Hart and McCollum of the Wisconsin Experiment Station and the reports of Edgar of the conditions in Belgium, it is evident that where variety of food is very limited and a single product forms a large portion of the ration white bread (about 75 percent or less of the wheat made into flour) would be very much safer than that made by reducing 80 percent or more of the wheat to flour. This is because of a toxic substance in the germ of the wheat kernel which could not then be eliminated. There is no reason however why a longer (a higher percentage) patent, a straight, or a low grade flour should not be more generally used.

Corn is used practically alone in some forms of bread. It is not often used as the only bread in the home and is in general favor only when warm. Mixed with wheat flour up to 25 percent it makes a satisfactory raised bread for general use. Its germ must be almost completely separated in the milling process to prevent souring when stored. Like whole wheat flour and others which are not bolted thru fine cloth it may become infested with moth or live weevil and therefore should be used as soon as possible after milling.

From the preliminary experiments published in the American Food Journal, June, 1917, by E. H. S. Bailey and W. S. Long it appears that flour from reduced rolled oats could be used to advantage in admixture with wheat at the present price of oats. In bulk they can be obtained at about half the price of wheat flour. The hull constitutes about 30 percent of the kernel. The higher the percentage of oat flour mixed with wheat flour the more compact the loaf becomes.

Kaffir, millet, and emmer may in time be given consideration by the public. Kaffir would rank along with corn. Millet is used extensively in Asia, Southern Europe, and Egypt and is fairly palatable in mixtures with wheat flour. Emmer makes a smaller loaf, darker in color, and stronger in both odor and flavor than wheat.

Table III was prepared to aid the reader in making an economic comparison of other cereals with wheat. Wheat brings the highest price per unit weight. If the entire kernels were used as food and prices remained relatively the same as the averages of the past all the other cereals would be competitors of wheat. There appears to be no data for comparing the cost of manufacture of the different flours. Of all these cereals, rye, corn, and wheat are the only ones extensively milled and the product marketed in the United States.

The selection of substitutes or supplements may be determined by personal preference rather than necessity. In either case the facts above cited may aid in making a choice.

TABLE III. ECONOMIC COMPARISON OF OTHER CEREALS WITH WHEAT

Crop	Pounds per bushel	Yield per acre, U. S. average, 40 years	Yield per acre in wt. of grain, wheat as the unit.	Cost per acre to produce, (from Minn. Ex. Station Bul. 145) 1908-1912	Cost per acre to produce, wheat as the unit	Average price per bushel 1911-14.	Average price per unit weight, wheat as the unit	Gross returns per acre, wheat as the unit
	Pounds	Bushels		Dollars		Cents		
Wheat	60	13.3	1.00	10.78	1.00	84.9	1.00	1.00
Rye	56	14.56	1.02	10.83	1.00	74.9	.945	.96
Barley	56	23.9	1.68	11.16	1.04	61.4	.775	1.30
Corn	56	25.	1.75	14.52	1.35	60.8	.767	1.34
Oats	32	27.95	1.12	12.02	1.12	40.0	.81	.90

MILLING VALUE OF BARLEY

By Thomas Sanderson

In the adoption of barley or any of the cereals as human food products, there are at least three important factors to be considered, namely; comparative food value, amount of increase of food products and the economic use of the same. The two latter items are considered in this article.

A sample of barley was secured from the Wisconsin Experiment Station. It was the common type and graded No. 3 under the North Dakota grades. It was designated as Wisconsin No. 5 a pure strain grown in Rock County, Wisconsin. This sample was divided into lots for a milling and baking test. Lot 1 was given laboratory number 3573 and Lot 2, 3573A, Lot 1 was milled on the large experimental mill equipped for milling wheat and Lot 2 was milled on the small two stand mill on which the bolting could be done on different fineness of bolting cloth to secure a higher percentage of flour. The following table shows the percentage of the different products obtained from these two lots.

TABLE IV. MILLING DATA ON BARLEY

Lab. number	Flour	Hulls	Other offal	Loss in milling	Barley per bbl. (196 lbs.) of flour	Bu. and lbs. per bbl.	
	Percent	Percent	Percent	Percent	Lbs.	Bus.	Lbs.
Lot 1—3573	30.24	22.75	44.45	2.56	649	13	25
Lot 2—3573A	68.60	17.07	9.40	4.93	286	5	46

A study of this table shows that barley cannot be milled successfully with the same equipment as wheat, and in the opinion of the writer a rye mill would not be an efficient equipment for producing results comparable with that of Lot 2 in the above table. Therefore, to secure results similar to those for Lot 2 a specially equipped mill will be required. It might be possible for the baker and housewife to do the blending, but more definite and satisfactory results would be obtained in a properly constructed blending plant.

Some millers may attempt to mill the barley as a blend with the wheat. This practice will prove a failure as is shown in Special Bulletin Vol. 11, No. 18, (North Dakota Experiment Station) page 313, issued August 1913 by the Food Commissioner. This test shows that the addition of 15 percent of barley to a No. 2 Northern hard red spring wheat milling sample reduced the flour 7.5 percent, increased the loss in milling 0.62 percent and gave a very slight reduction in the quality of bread; indicating that a very small amount of the barley had been bolted as flour, and that the bulk of it had gone into the feed.

If a scarcity of wheat should force the adoption of barley as a bread making grain, it would be possible to equip mills to produce flour comparable with that shown from Lot 2 or any intermediate grade between these two lots that might be desired; or it might be possible to get as high as 50 percent or more with the ordinary rye mill.

The United States Department of Agriculture gave the per capita consumption of wheat in 1910 as 5.31 bushels. Assuming the population to be one hundred million, the wheat requirement would be five hundred thirty-one million bushels. Allowing a milling yield of 68 percent of flour, would give 40.8 pounds of flour per bushel of wheat, or a total of 110,534,694 barrels. This figure will be used for these deductions as it is about the average percent of flour secured from the No. 2 Northern (Minnesota grades) wheat samples received from the 1916 crop. If it should be necessary to use as high a blend as 15 percent of barley flour milled as Lot 1, then 224,178,176 bushels of barley would be required. If milled as Lot 2, then 98,790,383 bushels of barley would be sufficient.

Market quotations at Chicago, Ill., for the week ending Sept. 29th, 1917, are reported on page 542 of the Northwestern Miller issued Oct. 3rd, as follows:—No. 3 Northern (Federal grades) Wheat $2.14 per bushel; barley, $1.165, Straight flour $10.35 per barrel, mill feed $1.77 per 100 pounds. Using these values for wheat and mill products a bushel of wheat yielding 68 percent of flour would give mill products valued at $2.49 per bushel and a gross gain for manufacture over the cost of the wheat of 35 cents per bushel.

Allowing 35 cents as the cost per bushel for the manufacture of barley into flour and the following arbitrary prices for the by products from the barley, as shown in Table IV, hulls 50 cents per 100 pounds, other offal $1.50 per 100 pounds, would give a cost price for the barley flour from Lot 1 of $7.964 per 100 pounds; and for Lot 2 of $4.333 per 100 pounds.

Therefore, the flour requirement for a year manufactured from No. 3 Northern wheat giving a yield of 68 percent of flour at $10.35 per barrel would cost $1,144,034,082.90. Manufactured from 85 percent of wheat and 15 percent of barley milled as Lot 1 it would cost $1,231,245,956.47 or $87,211,873.57 more by using the barley and would reduce the amount of wheat required 79,650,000 bushels. Manufactured from 85 percent of wheat and 15 percent of barley milled as Lot 2, it would cost $1,113,244,643.01 or $30,789,439.01 less by using the barley and would reduce the wheat requirement 79,650,000 bushels.

According to the above figures, it would be possible to use an amount of barley flour that would produce a loaf of bread very little below the quality of bread made from all wheat flour and at less cost than if made from all wheat flour.

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